CDM Smith

Memorandum

To: *Dave Stewart, P.E., Claire Maulhardt*

From: *John Aldrich*

Date: *July 27, 2015*

Subject: *Water Quality Modeling Plan*

Background

LTCP Approach and Pollutants of Concern Memorandum

On December 29, 2014, CRW submitted a draft Long-Term Control Plan (LTCP) Approach and Pollutants of Concern Memorandum, as required under Paragraph 16 of CRW's Partial Consent Decree (CD). In this Memorandum, CRW:

- Identified the Susquehanna River, Paxton Creek, and the Chesapeake Bay as waters receiving discharges from CRW's CSOs, and reviewed current water quality issues, standards, and compliance goals for each waterbody.
- Reviewed available, extensive water quality monitoring data and analyses on these waterbodies, particularly ongoing water quality assessments by PaDEP/Susquehanna River Basin Commission, water quality assessments performed for CRW's 2005 LTCP, and TMDL reports / load allocations for Paxton Creek and Chesapeake Bay.
- Based on the available water quality data, identified sediment, bacteria, dissolved oxygen/BOD, and nitrogen/phosphorus as the pollutants of concern (POCs) with respect to CRW's CSOs.
- Concluded, in consultation with EPA and PaDEP, that there is limited value to additional independent collection of water quality data by CRW solely for the purpose of developing CRW's LTCP.
- Indicated that CRW is open to participating in a collaborative approach to evaluating water quality conditions / improvements that might support additional water quality data collection and/or evaluation.
- Suggested that CSO LTCP development according to the presumptive approach "would probably meet" water quality standards (*CSO Guidance for Long-Term Control Plan,* USEPA, 1995), but deferred final determination of the LTCP development approach and level of

control until CRW's hydrologic / hydraulic (H&H) model of its conveyance system and collection system trunk sewers is completed and applied to evaluate a range of control levels, as specified in the partial CD.

Based on this memorandum, and subsequent discussions among CRW, EPA, and DEP, EPA concluded that CRW had met the requirements of Paragraph 16 of the Partial CD, and requested that CRW keep EPA/DEP informed of their progress at defining its LTCP approach and associated control levels.

Partial Consent Decree Requirements for Water Quality Assessment

Paragraph 17 of CRW's partial CD conditionally requires CRW to perform water quality assessments as part of its LTCP process. Specifically, the partial CD requires CRW to provide the following information:

> *17. Water Quality Modeling Plan. If CRW will utilize the Demonstration Approach in one or more Receiving Waters, then by August 1, 2015, CRW shall submit to EPA and PADEP a Water Quality Model Plan for review and approval pursuant to Section VI (Review and Approval of Deliverables), and shall implement the approved Water Quality Model Plan in accordance with the schedule included therein. For each water body in which the Demonstration Approach is to be used, the Water Quality Model Plan shall address:*
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> *a. Water quality modeling software to be employed;*
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> *b. Model configuration, including reaches to be modeled and segmentation and boundary conditions;*
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> *c. Calibration and validation, including events and data to be employed, quantitative and qualitative calibration criteria, and utilization of H&H Model outputs;*
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> *d. Use of the Water Quality Model to evaluate Typical Year in-stream conditions for each identified pollutant of concern;*
>
> *e. Schedule for model development and implementation, including integration into LTCP development consistent with other dates required pursuant to this Consent Decree.*

While CRW has not yet determined if it will apply a demonstration or presumptive approach for development of its LTCP, it recognizes the need to illustrate compliance with water quality standards as its CSO LTCP is developed and implemented. CRW is taking this opportunity to keep EPA/DEP informed, as requested, as its LTCP approach, and associated efforts to evaluate the water quality benefits of its CSO control program, continue to evolve.

Collaborative Efforts at Watershed-wide Water Quality Management

Paragraph 14 of CRW's partial CD states, among other things, that CRW's updated LTCP development "*. . . shall conform to the requirements of . . . EPA's Integrated Municipal Stormwater and Wastewater Planning Approach Framework Memorandum, dated June 5, 2012.*" CRW has initiated efforts to collaborate with several efforts occurring parallel to its LTCP development, which may potentially evolve into a more formal integrated plan for stormwater and wastewater planning:

- Within the City of Harrisburg, CRW is implementing an integrated approach to compliance with regulatory requirements for its combined sewer system, separate sanitary sewer system, and MS4, including a common regulatory framework for controlling discharges to its combined and separate sewer systems and a City-wide assessment of wet weather pollutant loading and pollutant control.

- The Lower Paxton Township Authority and Susquehanna Township Authority have contacted CRW about developing a collaborative approach for addressing wet weather wastewater management requirements, particularly with respect to the Paxton Creek Interceptor.

- Within the Paxton Creek watershed, CRW has initiated discussions with Lower Paxton Township and Susquehanna Township on a collaborative approach to addressing the Paxton Creek TMDL, including an agreement to reach out to other watershed stakeholders, consider an MOU in support of a collaborative approach, and evaluating water quality assessment approaches in support of development of detailed plans for achieving the TMDL.

- On the Susquehanna River, CRW has offered to collaborate with PaDEP and the Susquehanna River Basin Commission with regard to the ongoing evaluation of Susquehanna River water quality. For example, PaDEP offered to provide previously collected bacterial sampling data for CRW to use in support of its LTCP development.

- For the Chesapeake Bay, CRW, along with other political jurisdictions in Dauphin County, needs to meet a county-wide load reduction goal under the Chesapeake Bay TMDL, and anticipates that collaboration will be required to better define pollutant reduction goals of each political jurisdiction.

CRW envisions that, at some level, water quality evaluation / modeling will be needed to support these collaborative approaches. As these discussions are in their infancy, a formal proposal of a water quality modeling approach is premature at this time, however the remainder of this memorandum outlines the general water quality evaluation concepts currently envisioned by CRW.

Water Quality Compliance Objectives

The goal of CRW's LTCP and other related, collaborative wet weather pollutant control programs is to achieve DEP water quality standards and/or pollutant load reduction goals. Chapter 93 of the

Pennsylvania Code[1] defines designated uses of the Waters of the Commonwealth and the Water Quality Standards (WQS) for each use. Both the segments of the Susquehanna River and Paxton Creek receiving discharges from CRW's combined sewer system have been assigned the same designated uses:

Aquatic Life:	Warm Water Fishery (WWF), Migratory Fishes (MF)
Water Supply:	Potable (PWS), Industrial (IWS), Livestock, Wildlife, Irrigation
Recreation:	Boating, Fishing, Water Contact Sports (WC), Aesthetics

Sediment

Water quality standards for sediment are defined by the General Water Quality Criteria in paragraph 93.6 of the Pennsylvania Code:

> *(a) Water may not contain substances attributable to point or nonpoint source discharges in concentration or amounts sufficient to be inimical or harmful to the water uses to be protected or to human, animal, plant or aquatic life.*
>
> *(b) In addition to other substances listed within or addressed by this chapter, specific substances to be controlled include, but are not limited to, floating materials, oil, grease, scum and substances that produce color, tastes, odors, turbidity or settle to form deposits.*

The Paxton Creek TMDL determined that stream erosion constitutes over 85% of the sediment load in Paxton Creek, and projects that a 35% load reduction is needed to achieve the water quality standards under Pa Code 93.6. Similarly, the Chesapeake Bay TMDL projects that a 37% sediment load reduction is needed to achieve water quality criteria, and that 70% of this load reduction should be achieved from urban runoff sources. No sediment load reduction has been established for the Susquehanna River, so CRW assumes that achieving the Chesapeake Bay TMDL will address sediment-related water quality degradation in the Susquehanna.

Nutrients

Water quality standards for nutrients are also defined by the General Water Quality Criteria in paragraph 93.6 of the Pennsylvania Code. The Chesapeake Bay TMDL projects that a 30% phosphorus load reduction is needed to achieve water quality criteria, and that 40% of this load reduction should be achieved from urban runoff sources. The Chesapeake Bay TMDL also projects that a 33% nitrogen load reduction is needed to achieve water quality criteria, and that 50% of this load reduction should be achieved from urban runoff sources. No nutrient load reduction has been established for Paxton Creek or the Susquehanna River, so CRW assumes that achieving Chesapeake Bay TMDL limits will address nutrient-related water quality degradation in these waterbodies.

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[1] All such references refer to Title 25 of the Pennsylvania Code

Dissolved Oxygen

Water Quality Standards for dissolved oxygen in waterbodies classified as warm water habitat are defined in the Specific Water Quality Criteria in paragraph 93.7 of the Pennsylvania Code:

> *For flowing waters, 7-day average 5.5 mg/l; minimum 5.0 mg/l*

The Paxton Creek TMDL identifies DO as a pollutant of concern associated with CSOs, and states that compliance with LTCP requirements should address DO excursions in Paxton Creek. Our understanding is that Pa Code Section 96 requirements would apply to developing a wasteload allocation for biological oxygen demand and evaluating DO compliance. DO is not identified as a pollutant of concern in the Susquehanna River or Chesapeake Bay.

Bacteria

Water Quality Standards for fecal coliform are defined in the Specific Water Quality Criteria in paragraph 93.7 of the Pennsylvania Code:

> *Fecal coliforms/ 100 ml—During the swimming season (May 1 through September 30), the maximum fecal coliform level shall be a geometric mean of 200 per 100 milliliters (ml) based on a minimum of five consecutive samples each sample collected on different days during a 30-day period. No more than 10% of the total samples taken during a 30-day period may exceed 400 per 100 ml. For the remainder of the year, the maximum fecal coliform level shall be a geometric mean of 2,000 per 100 milliliters (ml) based on a minimum of five consecutive samples collected on different days during a 30-day period.*

Therefore, compliance with water quality criteria for fecal coliform is evaluated based upon a geometric mean of five consecutive samples during a 30 day period. Evaluation of compliance with this standard requires an evaluation of the probability of a wet weather discharge coinciding with a sampling event.

Approach to Water Quality Evaluation

This section documents how CRW envisions evaluating water quality compliance as it develops its CSO LTCP, as part of a collaborative approach to addressing a broad range of water quality issues. Our approach is not final, and in fact is expected to evolve as LTCP development progresses and collaborative initiatives advance. The purpose of this section is to provide EPA/DEP with an overview of CRW's current thinking relative to each requirement of the partial CD paragraph 17. Further refinements and revised drafts of this memorandum are anticipated.

Water Quality Modeling Software

There are several models and/or calculations needed to support water quality evaluations designed to project compliance with water quality standards:

- ***H&H Model of CRW's Conveyance and Major Trunk Sewer Systems.*** The H&H model will be used to develop CSO discharge hydrographs during typical year conditions. CRW might extend the H&H model into the MS4 system to estimated stormwater discharge flow hydrographs. Discharge volumes, peak flows, peak velocities, and durations will be developed, and statistical evaluations performed to define flow-frequency relationship for these discharges. The H&H Model will also be used to estimate reductions in discharges attributable to alternative green and grey control technologies. The USEPA Stormwater Management Model Version 5 (SWMM 5) is the selected H&H modeling software, as mandated under CRW's partial CD.

- ***Pollutant Loading Estimates.*** An MS-Excel Spreadsheet may be used to develop pollutant loading estimates, merging the CSO/MS4 discharge estimates generated by the H&H model with event mean concentrations (EMCs) for the pollutants of concern. EMCs will be based upon published regional and national statistics (e.g., EPA's National Urban Runoff Program (NURP), discharge characterization sampling data from Phase I stormwater permit applications, and CSO outfall sampling from communities similar to Harrisburg). Regional / national EMCs are appropriate to use for pollutant loading estimates because they compared well with CSO outfall samples collected in support of the 2005 LTCP prepared for Harrisburg.

- ***Pollutant Load Reduction Estimates***. The MS-Excel Spreadsheet pollutant loading model will be extended to incorporate pollutant load percent reduction factors. These pollutant load reductions may be compared with the TMDL pollutant reduction targets to determine if the targets have been met. Percent pollutant load reduction estimates will be based upon published regional and/or national statistics (e.g., EPA's National BMP Database, Pennsylvania BMP Manual, Penn State's MAPSHEDs model). H&H models will be used to determine flow frequency distributions to be used to determine the runoff volume, peak, and duration controlled by stormwater control measures under consideration. Alternatively, the MAPSHEDS model may be employed directly to develop pollutant reduction estimates, especially if the model used to prepare the Paxton Creek TMDL is provided to CRW.

- ***H&H Model of Paxton Creek***. A US Army Corps of Engineers (COE) HEC-HMS model of Paxton Creek, used to develop flow management targets for the Dauphin County Act 167 plan, is available to CRW and may be employed to evaluate flows, velocities, and shear stresses in Paxton Creek and evaluate flow management and/or bank stabilization alternatives targeted at reducing stream erosion, identified as the primary source of sediment in Paxton Creek. If necessary, the Army COE HEC-RAS stream hydraulic model, and /or associated HEC models to predict shear stresses, may be employed to develop refined projections of stream erosion mechanisms and control measure effectiveness. H&H modeling of Paxton Creek may be considered if a collaborative approach to TMDL compliance emerges.

- ***Receiving Water Quality Assessment***. A MS-Excel spreadsheet may be used to develop a receiving water quality assessment model to estimate the potential impact of a range of alternative control alternatives on attainment of water quality standards in the receiving

waters for each pollutant of concern (POC) with a specific water quality criteria listed in PaCode Section 93.7. The receiving water quality assessment model is expected to employ a completely mixed reactor, mass balance approach to estimate, for the supposed future controlled conditions, the in-stream Receiving Water concentration of each POC by combining flows and pollutant loads from base flow, stormwater runoff, and CSO discharges. The screening tool is intended to perform complete mixing estimates on an hourly basis for the typical year. The receiving water quality assessment model may be applied on Paxton Creek and the Susquehanna River using monitored stream flow data and/or model projections.

Model Configuration

The H&H model of the CRW's conveyance and trunk sewer systems will be configured to represent each CSO regulator / outfall, interceptor sewer, pumping station, and trunk sewer, as defined in the partial CD. It will be developed to represent rainfall runoff entering the combined sewer system within Harrisburg, and might be extended into the separate sanitary sewers of the jurisdictions discharging to CRW's conveyance system, based upon the agreed-upon collaboration plan with each township's authority. Pollutant load and load reduction models may be established for each CSO and, potentially, MS4 outfall in the City of Harrisburg.

The existing H&H model of Paxton Creek currently covers the entire watershed of the Creek. Refinements and/or additions to this model configuration will be determined to support the needs of any watershed-wide collaboration that emerges for addressing the Paxton Creek TMDL.

The receiving water quality assessment model will be applied to the downstream portion of Paxton Creek that receives CSO discharges, and to the east shore of the Susquehanna River within and immediately downstream of Harrisburg. Previous water quality evaluations indicate that the Susquehanna River in and downstream of Harrisburg acts as three shallow, parallel rivers (east shore, central, west shore), with little mixing between them. As such, receiving water assessments can focus on the east shore of the Susquehanna, independent of the remainder of the river. Receiving water assessments may be designed to focus on dissolved oxygen and bacteria, the POC's where a TMDL has not already established load reduction targets.

Calibration and Validation

CRW is currently collecting the data needed to calibrate and validate the H&H Model of its conveyance and major trunk sewer system. Calibration /validation data consists of eight rainfall gages, gage-adjusted radar rainfall data, depth/velocity meters at 13 CSO regulators and 13 locations along CRW's interceptor sewers. Calibration / validation protocol are provided in the partial CD.

Receiving water quality assessment models will be compared with available historic water quality data collected on the Susquehanna River and Paxton Creek, as necessary to illustrate that the models serve as credible planning tools.

In-Stream Condition Evaluation

The Paxton Creek H&H model, if used, will be applied to evaluate existing hydraulic conditions in Paxton Creek, correlated with visual observations of erosion and sedimentation along the Creek, and could be used to evaluate if changes in flow regime and/or bank stabilization are able to adequately meet Paxton Creek TMDL targets under a range of control scenarios.

The receiving water quality assessment model is expected to produce a conservative assessment of water quality control as it does not account for travel time or in-stream water quality processes such as bacteria decay, oxygen dynamics, nutrient transformations, particle settling, and other physiochemical processes. For the dissolved oxygen (DO) assessments the hourly concentration time series in each Receiving Water will be analyzed to estimate the percent of time each standard was not attained in the typical year. To evaluate the attainment of the fecal coliform standards, a sampling algorithm in the assessment tool will be developed to generate a series of random sample groups, with each sample group containing five samples on different days over a 30 day period. The geometric mean of each sample group will be calculated to compare to the 200 cfu/100 mL and 2,000 cfu/100 mL standards for the recreational and non-recreational seasons, respectively. In addition, the percent of samples exceeding 400 cfu/100 mL in each sample group during the recreational season will be calculated. For each surrogate control alternative, the sampling algorithm will be run for 10,000 iterations to generate a large sample population. The number of sample groups exceeding each standard will be divided by the total number of sample groups to calculate the frequency of standard exceedances. This exceedance frequency will be considered representative of the probability of not meeting the water quality standard under the surrogate control strategy.

In-stream physical and biological data has been collected for several years on the Susquehanna River and Paxton Creek, and is considered to represent existing conditions in each waterbody. CRW understands that PaDEP will continue to collect this data. As the LTCP is developed a post-construction monitoring plan will be developed that may include further physical and biological sampling at existing sites and/or additional sites targeted to assess control effectiveness. We understand that DEP will base compliance with water quality standards for warm water habitat based upon these physical / biological assessments.

Schedule

The various models and assessment tools will be prepared and available to support LTCP development and associated activities to determine controls needed for compliance with the TMDLs. According to CRWs partial CD, LTCP development is scheduled to occur between April 1, 2017 and April 1, 2018. Interim dates for developing the necessary tools, outside of those established in the partial CD for H&H model development, are dependent upon ongoing discussions with regard to regional / watershed-wide collaboration.